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NINTENDO WII REMOTE CONTROLLER IN HIGHER EDUCATION: DEVELOPMENT AND EVALUATION OF A DEMONSTRATOR KIT FOR E-TEACHING

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Abstract. The increasing availability of game based technologies together with advances in Human-Computer Interaction (HCI) and usability engineering provides new challenges and opportunities to virtual environments in the context of e-Teaching. Consequently, an evident trend is to offer learners with the equivalent of practical learning experiences, whilst supporting creativity for *both* teachers and learners. Current market surveys showed surprisingly that the Wii remote controller (Wiimote) is more widely spread than standard PCs and is the most used computer input device worldwide, which given its collection of sensors, accelerometers and bluetooth technology, makes it of great interest for HCI experiments in e-Learning/e-Teaching. In this paper we discuss the importance of gestures for teaching and describe the design and development of a low-cost demonstrator kit based on Wiimote enhancing the quality of the lecturing with gestures.

Keywords: Human-computer interaction, e-learning, Wiimote

1 INTRODUCTION AND MOTIVATION FOR RESEARCH

1.1 Is Minority Report Still Too far Away?

In "Minority Report", a scientific fiction (sci-fi) movie directed by Steven Spielberg in 2002, Tom Cruise as Chief John Anderton danced gracefully through a plethora of evidences in a 3-D virtual reality world presented in front of him. He touched things with his "magic fingers", opened and examined them, and threw away less important ones by a single wave of hands. This scenario is, of course, still far beyond the current capabilities of the Human-Computer Interaction (HCI) that average computer end users experience on a day-to-day basis and indeed only exists in this sci-fi movie. Mouse and keyboard are still the only means available to a majority of end users, along with touch screens in purpose-built devices, e.g. smartphones, PDAs, portable game consoles and certain types of information appliances. In the last seven years, technology has brought us closer to this fascinating scenario, though we, as ordinary users, are still a significant distance away from becoming Chief Anderton. The desire to have "magic fingers" is not driven purely by sci-fi fantasies. Instead, explicit and concrete application scenarios and evident improvement in HCI have been the main inspiration behind recent developments. Among others, e-learning, especially game based learning approaches, is a major driving force [5, 15].

1.2 Teaching and the Importance of Gestures

Electronic learning (e-learning, also referred to as technology-enhanced learning) has a long history dating back to the early sixties [11]. It gained substantial attention recently due to the advances of the Internet and virtual reality [19]. As in real classrooms, the outcome of learning activities is influenced by the effective delivery of learning materials, which can in turn be significantly influenced by the chosen method of communication.

In real life, we communicate primarily through speech and gestures. Consequently, gestures are an important part of non-verbal communication within demonstration and presentation tasks and are essential for human cognition. It is evident that co-speech gestures can support the construction of a complete mental representation of the discourse content, leading to an improved recollection of conceptual information [3]. Even though culture variants present, gestures can be seen as a ubiquitous element of human communication across cultures [16]. Studies showed that gestures impinge on students' comprehension of instructional discourse, thereby influencing students' learning capacity. Hence, teachers' gestures can indeed explicitly and implicitly facilitate student's learning [20]

1. as an expressive and informative means to aid speech and
2. through increasing the learning efficiency by students' mimicking teachers' gestures.

However, gestures depend on various factors including personality, cultural background, educational, social, and geographical surrounding, and especially the level of previous knowledge [8]. A full understanding of the impact of gesture-based HCI implies a multi-disciplinary effort. Such studies call for low-cost and convenient prototypes that average users can easily assemble and experiment.

In this paper, we discuss the importance of gestures for teaching and report on the development of a low-cost application and demonstrate that it can enhance the quality of the lecturing process [10]. Merging these gestures by use of unified interfaces can offer the possibility of implementing a non-verbal communication code for a certain purpose; in our case the transfer of information, within the scope of the demonstration and the presentation of the teaching subjects, tracking gestures will be used to highlight and underline the essence of the learning material presented. For example, just pointing to a particular location of an object saves time and sometimes can be more efficient than a longwinded verbal description.

2 THEORETICAL BACKGROUND AND RELATED WORK

E-learning has long been considered merely as an extension of conventional classroom based learning with teachers presenting and delivering learning materials and students accepting and consuming such materials. The Internet, multimedia, and mobile technologies have jointly added new elements into this conventional model by making more materials available to a wide range of public, enriching the delivery channels, and allowing students to participate whenever and wherever they can [9].

We do not deny the advantage of such learning paradigm and the improved distance learning experience that new technology can benefit us. However, it is our contentions that so far e-learning is largely similar to what we have experienced in a real classroom and simply mimicking classrooms in the virtual world is *not* the future of e-learning whose potential cannot be fully manifested unless one fully abandons the "classroom" cliche. We argue that there is a critical element missing from current e-learning scope: *participation*. In real life, classroom learning only accounts for a small part of our knowledge acquisition – we acquire the rest through participating in problem solving activities. Formerly, apprentices learnt by observing and acting together with their masters (cognitive apprenticeship, see e.g. [2]).

In modern societies, we learn and solidify our knowledge by participating in various events and we pass knowledge onto others by demonstrating what we have learnt through activities. Although, nowadays, the master-apprentice learning pattern is not as prevalent as before, participation is still critical for acquiring knowledge, in particular practical knowledge, e.g. dancing skills, sports, medicine, etc. Participatory learning has certainly caught the attention of, and started to infiltrate, classical e-learning.

For instance, Second Life [21] has become a learning phenomenon involving virtual participation. Not bound by any physical conditions or even physical laws, one's avatar can participate and experience in almost any events and activities. Yet one minor thing has ruined all the greatness. Until recently, the dominant input devices interfacing users and Second Life were still mouse, joystick, touch screens, etc., restricting our participating experience to an unreal one. Our hope hovered as Wiimote (or Wii Remoter) appeared. Although being developed originally as the input device/remote controller of the Wii game console (`http://wii.com/`), Wiimote has an unexpected, far-reaching impact on e-learning. The consequence is yet to be fully understood. However, we must bear in mind that learning (electronic or otherwise) is a cognitive, social process while teaching is a didactical, social process. At this moment there is a lack of experience and evaluation of the benefits and risks of e-teaching techniques [14]. The use of Wiimote, therefore, is subject to extensive evaluation and the work presented in this paper is one of the early attempts.

Despite the fact that Wiimote was originally designed and marketed as only a gaming input device, users soon discovered the distinctive advantages of Wiimote which can be seen from the following aspects.

Availability. Wiimote has been distributed together with the game console and can also be purchased separately from almost any electronic shop. With the help of online shopping, obtaining Wiimote becomes even easier.

Cost effectiveness. Wiimote is relatively cheap (roughly 35 Dollars or 25 GBP in July 2009) compared to other devices offering similar functionality. This low retail price encourages a further growth of the Wiimote community.

Popularity. Since Wiimote, and the Wii game console, was released in 2005, a mature community has been established with programmers, designers, HCI experts, hackers, etc. exploring and experimenting with new applications based on Wiimote. Code repositories, online tutorials, and well-established forums (e.g. `www.wiili.org`) have pushed the use of Wiimote to an entirely new frontier.

Extensibility. Wiimote communicates with the game console through a standard Bluetooth interface. It also features an expansion port allowing various attachments (e.g. Wii Wheel, Nunchuk) to further enrich the functionality.

Open Source. Unlike the equipment from other gaming device manufacturers, Wiimote's Bluetooth wireless link allows one to connect it to virtually any device that is Bluetooth enabled. Data collected from Wiimote can then be processed by such devices taking full advantages of their computational power.

The built-in motion sensors make Wiimote perfectly suitable for realistic training simulation. For example: in Second Life, Wiimote makes it possible to experience an almost real-life environment at a very low cost. Companies, e.g. construction, power plants, etc., have already started using a combination of Wiimote and Second Life for early stage, hands-on job training. The feeling of reality in such simulators, however, is still diminished by the fact that one has to hold the Wiimote and thus cannot mimic actions requiring finger movement and grip-and-release. This shortcoming inspired us to explore "hands-free" scenarios with Wiimote and the applicability in e-learning. Our observation is simple: being able to convey information through hand and finger movement enhances the e-learning experience in both the virtual classroom and the "hands-on" training simulators. Imagine that one can "touch/toggle" buttons on a virtual control panel in the same way as in real-life; one can move things by gripping and releasing; and one can flip the pages of a virtual book in the same way as one reads a real book. Wiimote, though not the first device facilitating such functionalities, represents a major step towards lowering the cost barrier and grant access to the mass population.

An additional benefit of using the tracking gestures method is the adaption of computers to users with special needs. Thus far, the advance in computational power has been less beneficiary to users with special needs than to average ones, manifesting the long lasting Digital Divide among sub-populations of humans. This special group needs a much wider support for additional input channels than average users – the amount of information and the possibilities for communication possessed by this special group are much more limited due to for instance hearing and vision problems and deteriorated dexterity. Members of the special group include not only less-abled individuals but also those who are suffering from aging problems and those having less chance to practice with such input devices as keyboards and mouses. For this subpopulation, not being able to proficiently interact with computers or computing devices has evident negative, and even devastating, impact on their daily life. Consequently, there is a strong need to support end users with special needs by providing them with additional devices and interfaces, which enable them to work on an equal footing with average users [4]. Our work can be considered as a step forward along the line of research towards eliminating, or moderately speaking, alleviating Digital Divide.

In this paper, we piloted how Wiimote can be used in presentations involving a significant amount of gesture-based communication. Although our work has not demonstrated the diverse and full capacity of Wiimote, we show how a simple extension to Wiimote can lead to significant improvement in usability. We focused on the following research questions: "What is the central advantage, for both teachers and students, of using intuitive interface devices such as a Wiimote controller?", "How can Wiimote controllers enhance current e-Teaching methods?", and "What basic design considerations must be taken into account?". Answers to such questions would also help us better understand the general strengths and weaknesses of Wiimote based gesture tracking as an input channel.

3 LEVERAGING THE WIIMOTE IN A DEMONSTRATOR KIT

Following the research recommendations presented by Stephanidis and Salvendy [18], we tested whether, and to what extent, the use of gestures during real life university teaching settings enhances the efficiency of lecturing as well as the learning in large traditional lecturing rooms. Apart from purely technological testing on site, we additionally used interviews and short questionnaires, supported by usability inspection methods and by additional video analyses [1, 7].

3.1 Study Setups

As the main user interface device for our experiments, we used the standard Wiimote obtained from the market, which is equipped with a 128×96 monochrome camera and an infrared (IR) pass filter at one end of the device. Additionally, Wiimote also includes a built-in processor capable of tracking up to 4 moving objects at a frequency of 100 Hz. These features classify Wiimote as a very feasible sensor for infrared projection planes. The on-board $8\times$ sub-pixel analysis is used to provide valuable resolutions (up to 1024×768) for the tracked objects. The IR pass filter detects reflecting sources up to a wavelength of 940 nm with approximately the double intensity of equivalent 850 nm sources. However, a known shortcoming of the IR filter is that it does not resolve very well at very close distances. The IR sensor alone, without the filter, can track any bright object. Additionally, the Wiimote includes a Bluetooth interface for communication, which enables it to connect to any Bluetooth compatible devices.

Using the built-in features and adequate existing open source library, we aimed at implementing communication through finger tracking and capturing of infrared reflections. Every infrared reflecting surface can be used as a projection surface (computer screens, beamer projections etc.). When native mechanism was not powerful enough, a simple LED array, made of long-range infrared light diodes, was used to enhance the range and the supported working distance.

This approach offers the possibility of interaction once the tracked movements – such as mouse movements, mouse clicks, selections or keyboard commands – are interpreted into the boundaries of the operating system. The implemented gesture recognition enables interaction, which enhances the learning and teaching process and information transfer between the participants.

We developed a Wii technology-based demonstrator kit as a testbed on multimedial teaching methods. This kit includes the Wiimote and the aforementioned infrared diode array as sensors and reflecting finger pads as interaction hubs. The finger pads amplify the signals reflected from finger tips and are used as pointers and as interfaces for gestures, while the Wiimote itself is used in one of the two tested setups in order to simulate a hand free mouse and an interaction tool on projected surfaces. For connection, communication and parameterization of the hub, we developed a special demonstrator kit.

We tested two different setups. In the first setup, the Wiimote served both as the capturing and the input device. The IR LED array, with its radiated IR field, was the static sensor reference. In the second setup, the Wiimote acted as a passive sensor field receiver enhanced by the radiation strength of IR LEDs array. The software component supporting the two setups is *Wiimote Control Desk*.

The *Wiimote Control Desk* application was developed based on the code of Wiimote *Whiteboard*, originally programmed by J. C. Lee [13]. Lee's intention of this code was for controlling and tracking an IR Pen using an IR sensor of Wiimote as the capturing device so as to simulate a white board. For the purposes of finger tracking and mouse remote control it was slightly adapted with some new features. The *Wiimote Control Desk* was implemented using the Visual Studio C# Express edition, freely available at `http://www.microsoft.com/express/vcsharp/`. It runs on Microsoft .NET Framework 2.0. The communication inside relies on the Managed Wiimote library for .NET, originally developed by B. Peek (available at `http://www.codeplex.com/WiimoteLib`). The Application Programming Interface (API) uses Bluetooth to communicate with Wiimote and to retrieve and handle the various states of the Wiimote components. The Wiimote is treated as a Human Interface Device (HID) compliant device when connected to a regular PC. The API takes advantage of the P/Invoke mechanism. In general, there are two different ways to retrieve data from the API: using events or using polling. We opted for the event based approach at the currently implementation. Hence, the Wiimote Control Desk can be operated corresponding to setups in two different modes: Controller mode and Presenter mode.

The objective of implementing the *controller mode* was to use the Wiimote as both a pointing and presenter device, similar to a hand free mouse. An appropriate Controller Mode setup is illustrated in Figure 1 b). The IR LED array was used as a capturing background device (see discussions in Section 3.1 and Figure 1 a)). For this controller mode, some of the Wiimote's standard buttons had been reprogrammed to support mouse-like functionality. For instance, the button "A" emulates a left click of a mouse and the button "B" emulates a right click. Double-click can be simulated by pressing "A" twice with a medium interval. The "navigator cross button" provides the mouse selection and, for example, the navigation of slides in Powerpoint presentations.

Finger tracking support requires the usage of a so-called *presenter mode*. This mode enables end users to navigate through presentation slides in Powerpoint or similar presentation tools or any other application that supports the forward or back function based on keyboard events. Basically this is done by firing the left or right keyboard keys respectively to the relative position of the mouse cursor on the screen pointed through the finger tracking pad. Switching to this mode can be done manually only if a running PowerPoint or any other presentation software is in presenting mode; otherwise the request is ignored. Usually the switching happens automatically when the system notices that the conditions are met. Mode migration is also visualised by changing the cursor shape, i.e. from an arrow cursor to a cross direction cursor.

A further functionality is available in addition to the Presenter Mode. This functionality is revealed by switching to Presenter Mode and offers users the possibility of configuring for trigger ranges of "left" (next) and "right" (previous) commands, intended for the navigation of the presentation's slides. The numbers in the text boxes represent the time ticks. For example one second can last approximately from 25 to 50 ticks depending on users' preference. Holding the mouse cursor positioned by the tracked reflecting finger pad beyond the length of time specified as the boundary range of ticks will trigger the switch into the next or previous slide, depending on where the last cursor position was detected: on the left or right half of the screen. The *Presenter Mode* setups are shown in Figures 1 b) and 1 c).

The IR LED array was built using highly reliable SFH 485 IR Emitter Diodes from Siemens[1]. The average wavelength at peak emission is 880 nm, which is sufficient for the the Wiimote's IR sensor. The IR LEDs array requires a constant 3 V (1 A) power supply. Figure 1 a) illustrates the final arrangement of IR LED Array used in our experiment, with a hole in the middle.

3.2 Study Results

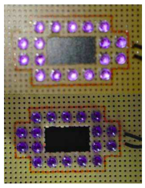
The first setup considers finger tracking as a natural gesture interpreting method. The finger tracking setup consists basically of three main components: the IR LEDs array, Wiimote, and Wiimote Controller Desk (Figure 1 b)).

The IR LEDs Array radiates an IR Field towards the observer standing in front of the setup. The IR sensor of Wiimote is placed behind the array looking through the hole provided at the center of the board. In this way, the sensing area of Wiimote's sensor is enhanced by the strength of the emitter diodes in the IR LED array. This increases the area covered by the Wiimote, which would otherwise be too narrow.

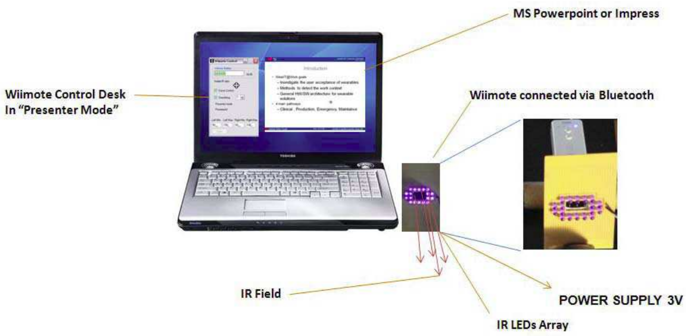
A reflective tape, commonly used with light barriers, was mounted on a standard bottle plastic cap as the reflecting device. As part of the *Wiimote Controller Desk* implementation, the smoothing mechanism calculates and filters out the falsely sensed points in order to interpolate the movement of the single tracking path, thus smoothing out any unintentional tremors. The bottom line of this setup is to set the appropriate position of the mouse cursor on the screen, corresponding to the appropriate position of the reflective finger pad in the area covered by IR field. Depending on the position and length of appearance of the mouse cursor, *Wiimote Controller Desk* interprets and fires the corresponding actions.

This setup is only used for navigating through presentations in MS PowerPoint or Open Offices Impress. After starting, the *Wiimote Controller Desk* toolkit checks

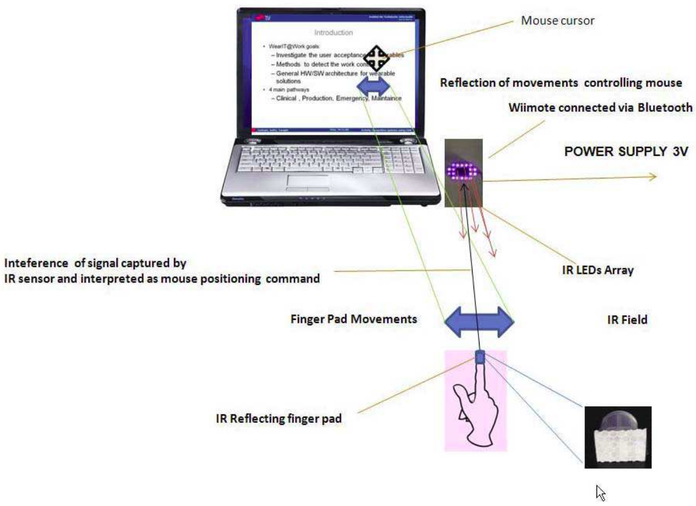
[1] `http://www.alldatasheet.net/datasheet-pdf/pdf/45674/SIEMENS/SFH485.html`.



a)



b)

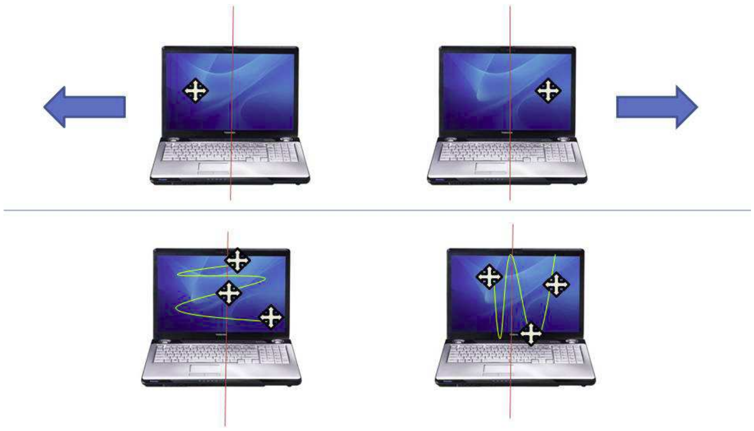


c)

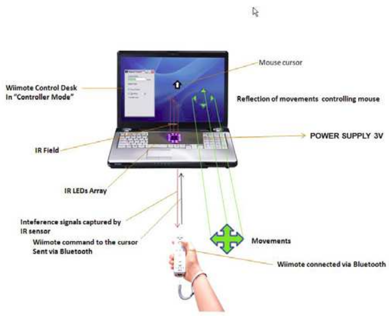
Fig. 1. Finger tracking with Wii Romote; a) IR LED array, b) Sensor setup for finger tracking, c) Finger tracking in action

continuously at short intervals whether there are any common presenter applications, such as MS PowerPoint or Open Offices Impress running. In the case that an instance of these applications has been started, it switches automatically to the Presenter Mode.

Bringing the reflecting pad into the radiation field of IR array activates the Wiimote IR sensor to recognize the reflecting point and its movement. The position of the finger pad is then interpreted and projected on the computer screen.



a)



b)

Fig. 2. Wireless presentation control with Wii Romote; a) Moving patterns, b) Setup for using the Wiimote as a pointing and control device

In order to simulate the "forward" and "backward" commands properly in a running presentation, it is necessary to calibrate the *Presenter Mode* in the *Wiimote Controller Desk* by setting up the appropriate values for ticks ranges.

Switching slides can be triggered by holding the projected cursor on the right or left side of the screen for a given time interval and then removing it from the field, e.g. by hiding or covering the reflecting area of the finger pad. A proper setting of the time interval is acquired based on personal preference and previous experience. Depending on where the cursor is detected, this is interpreted either as a command to switch to the previous slide or to the next one.

All other moving or positioning patterns and time intervals will only lead to a mouse pointing action. Both behaviors are depicted in Figure 2 a).

The setup for using the Wiimote as a pointing and presentation input device is depicted in Figure 2 b). Basically, this second setup consists of a IR LEDs Array positioned in front of the screen of targeting projecting surface. The field rays from the IR LEDs array should be aligned vertically upwards along the screen of the projection area. The *Wiimote Controller Desk* should be also up and running. Operating in this setup, the Wiimote can be used instead of a mouse, supporting all the basic mouse functions, such as cursor pointing, left click, double click and right click. Additionally, the navigation button enables the Wiimote to simulate the operations of the selection and forward or backward action of the keyboard arrow keys (e.g. when running presentations or image galleries).

The principle of the projection of mouse movements is very simple: The field vertical to the projection area radiated by the IR LEDs Array (here notebook display) represents a static reference to the moving IR sensor on the Wiimote. As long as the Wiimote is moving, its perception of the constant IR field in front of the display deviates at the point of observation. This deviation will be recognized as an isolated IR signal and reported to the *Wiimote Control Desk*, which treats this information as an instruction to point the mouse on the appropriate place on the projection screen. The Wiimote's button "A" is used for the left click and pressing it quickly twice has the same effect as regular double click of the mouse. Button "B", located underneath, triggers the right click.

4 CONCLUSION AND FUTURE WORK

Our demonstrator kit was experimented as a presentation tool during various lessons and practical lab sessions at Graz University of Technology. It showed that Wiimote is a very handy mouse controller and pointing device with a wider range than the usual wireless mouse. Moreover, it was used as an interactivity and cooperation tool during learning and discussion tasks using a visual tracking of mouse movements on electronically shared whiteboards. In comparison to the classic approaches, our method allows *direct intuitive cooperation* between all participants within the learning process. Consequently, such an approach offers more comfort and provides more flexibility in everyday e-learning and e-teaching activities. Furthermore, there is no comparable low cost product other than Wiimote, which contains a higher or equal grade of interactivity and such a wide application area that would be as suitable for these purposes. Altogether, it can be emphasized that Wiimote is a fascinating collection of sensors that can be used for many purposes, even for recognizing gestures, and which can be adapted with very low cost using adequate open source libraries available on the Internet. Using Wiimote as a pointing and mouse device works well but demands more work in order to capture the mouse positions and moves more accurately. Using the approximation of motions could result in improved smoothing, an area which should be considered for future development considering area of application targeted. Future research will include the use of IR LEDs with a lower wave length to assess the achievement of a wider range and more accurate isolation of tracking points and increasing the number of LEDs in the array, to see whether this increases their accuracy. The main area of research will be other methods of triggering commands. Using time as a basis for command delegation shrinks the potential of possible operability range massively. Improving the personal gesture interpretation capturing the data from Wiimote's accelerometer should be also considered an important research issue.

Tracking general basic gestures relevant for e-teaching and e-learning tasks works stably for several meters (3–5 m) distance to Wiimote (depending on the light conditions and the position of Wiimote) with an enhanced radiation field as shown in the finger tracking example. While testing different setups, heuristic experience showed that placing the Wiimote beside the computer at a height between 1 and 1.5 m, and at an angle between 45–60 degrees, offered the best setup.

While, obviously, there are many important issues to address, the crux of our future work lies in the enrichment of current gesture-based e-learning and e-teaching scenarios. Using gesture control in presentation is only the first step towards fully exploiting Wiimote's fascinating potential functionalities. For instance, it has been demonstrated that multi-point tracking can be achieved using Wiimote [12]. This opens the door to many high interactive applications in e-Learning and virtualized training, as well as other areas such as assistant living.

REFERENCES

[1] Brun-Cottan, F.—Wall, P.: Using Video to Represent the User. Communications of the ACM, Vol. 5, 1995, pp. 61–71, 1995.

[2] Collins, A.—Brown, J. S.—Newman, S. E.: Cognitive Apprenticeship: Teaching the Crafts of Reading, Writing and Mathematics. In L. B. Resnick (Ed., Knowing, learning and instruction: Essays in honour of Robert Glaser, pp. 453–494, Hillsdale (NJ), Lawrence Erlbaum 1989.

[3] Cutica, I.—Bucciarelli, M.: The Deep Versus the Shallow: Effects of Co-Speech Gestures in Learning from Discourse. Cognitive Science, Vol. 5, 2008, pp. 921–935.

[4] Debevc, M.—Peljhan, Z.: The Role of Video Technology in On-Line Lectures for the Deaf. Disability and Rehabilitation, Vol. 17, 2004, pp. 1048–1059.

[5] Ebner, M.—Holzinger, A.: Successful Implementation of User-Centered Game Based Learning in Higher Education: An Example from Civil Engineering. Computers and Education, Vol. 3, 2007, pp. 873–890.

[6] Gellersen, H. W.–Schmidt, A.—Beigl, M.: Multi-Sensor Context-Awareness in Mobile Devices and Smart Artifacts. Mobile Networks and Applications, Vol. 5, 2002, pp. 341–351.

[7] Holzinger, A.: Usability Engineering for Software Developers. Communications of the ACM, Vol. 1, 2005, pp. 71–74.

[8] Holzinger, A.—Kickmeier-Rust, M.—Albert, D.: Dynamic Media in Computer Science Education, Content Complexity and Learning Performance: Is Less More? Educational Technology and Society, Vol. 1, 2008, pp. 279–290.

[9] Holzinger, A.—Nischelwitzer, A. K.—Kickmeier-Rust, M. D.: Pervasive e-Education Supports Life Long Learning: Some Examples of X-Media Learning Objects. 2006, available at `http://www.wccee2006.org/papers/445.pdf`, last access: 2009-04-18.

[10] Holzinger, A.—Softic, S.—Stickel, C.—Ebner, M.—Debevc, M.: Intuitive e-Teaching by Using Combined HCI Devices: Experiences with Wiimote Applications. In LNCS 5616, pp. 44–52, 2009.

[11] Lawson, D. R.: Who Thought of It First? A review of historical references to programmed instruction. Educational Technology, Vol. 10, 1969, pp. 93–96.

[12] Lee, J. C.: Hacking the Nintendo Wii Remote. IEEE Pervasive Computing, Vol. 3, 2008, pp. 39–45.

[13] Lee, J. C.—Hudson, S. E.—Summet, J. W.—Dietz, P. H.: Moveable Interactive Projected Displays Using Projector Based Tracking. In 18^{th} annual ACM symposium on user interface software and technology. ACM, 2005.

[14] Peter, G. N.: Risks of e-Education. Communication of the ACM, Vol. 10, 1998, 136 pp.

[15] Robertson, J.—Howells, C.: Computer Game Design: Opportunities for Successful Learning. Computers and Education, Vol. 2, 2008, pp. 559–578.

[16] Roth, W. M.: Gestures: Their Role in Teaching and Learning. Review of Educational Research, Vol. 3, 2001, pp. 365–392.

[17] Schlömmer, T.—Poppinga, B.—Henze, N.—Boll, S.: Gesture Recognition With a Wii Controller. In Proceedings of the 2^{nd} International Conference on Tangible and Embedded Interaction (TEI 08), ACM 2008.

[18] Stephanidis, C.—Salvendy, G.: Toward an Information Society for All: HCI Challenges and R & D Recommendations. International Journal of Human-Computer Interaction, Vol. 1, 1999, pp. 1–28.

[19] Thomas, P.—Carswell, L.—Price, B.—Petre, M.: A Holistic Approach to Supporting Distance Learning Using the InternetTtransformation, Not Translation. British Journal of Educational Technology, Vol. 2, 1998, pp. 149–161.

[20] Valenzeno, L.—Alibali, M. W.—Klatzky, R.: Teachers' Gestures Facilitate Students' Learning: A Lesson in Symmetry. Contemporary Educational Psychology, Vol. 2, 2003, pp. 187–204.

[21] Wheeler, M.: Developing the Media Zoo in Second Life. British Journal of Educational Technology, Vol. 3, 2009, pp. 427–443.

[22] Zhang, D. S.—Zhao, J.—Zhou, L.—Nunamaker, J. F.: Can e-Learning Replace Classroom Learning? Communications of the ACM, Vol. 5, 2004, pp. 75–79.

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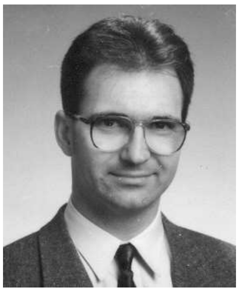

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